

# NASA TECH BRIEF

*Lewis Research Center*



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## Nonmetallic Impurities Improve Mechanical Properties of Vapor-Deposited Tungsten

Certain mechanical properties of vapor-deposited tungsten can be improved by the selective incorporation of various nonmetallic impurities. The addition of trace quantities of carbon, nitrogen, or oxygen can significantly increase both the low- and high-temperature yield strength without greatly affecting the ductile-to-brittle transition temperature (DBTT).

These results represent the basic findings of a study aimed at achieving greater control of the properties of vapor-deposited tungsten. Specifically, it was found that the addition of carbon in concentrations of from 250 to 300 ppm raised the low-temperature yield strength from  $345 \times 10^6 \text{ N/m}^2$  (50 ksi) to nearly  $1380 \times 10^6 \text{ N/m}^2$  (200 ksi) and the yield strength at  $1800^\circ\text{C}$  from less than  $27.6 \times 10^6 \text{ N/m}^2$  (4 ksi) to about  $62.1 \times 10^6 \text{ N/m}^2$  (9 ksi), while the DBTT stayed below  $200^\circ\text{C}$ . Nitrogen additions within the additive range studied were equivalent to carbon in producing strength increases. The effect of oxygen on high- and low-temperature yield strengths was somewhat less.

Two principal techniques were used to add the desired impurity: One involved gas-metal reactions to introduce an impurity into previously deposited tungsten; the other involved the codeposition of the impurity with the tungsten. In the case of carbon, the first technique was performed by immersing vapor-deposited tungsten specimens in a rich mixture of methane in hydrogen gas at about  $1650^\circ\text{C}$ , to form a carbon-rich surface layer. The specimen was then annealed at a higher temperature to establish an equilibrium solid solution in the metal, and the remaining carbide layer was machined from

the surface before any property measurements were made. The second technique entailed adding methane to the hydrogen and tungsten hexafluoride gas mixture normally used in tungsten vapor deposition.

These two techniques were selected in order to separate the effect of the additive from that caused by any alteration introduced by second-phase nucleation if the additive is incorporated during deposition.

### Notes:

1. Background information on the process of tungsten vapor deposition is presented in NASA Tech Brief 67-10232. A practical application of this process in forming large mechanical structures from refractory metals is presented in NASA Tech Brief 71-10212.
2. Requests for further information may be directed to:

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### Patent status:

No patent action is contemplated by NASA.

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